

SEXUAL MORPHS OF *APHIS ACAENOVINAE* EASTOP, 1961 (HEMIPTERA: APHIDIDAE: APHIDINAE)

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Abstract

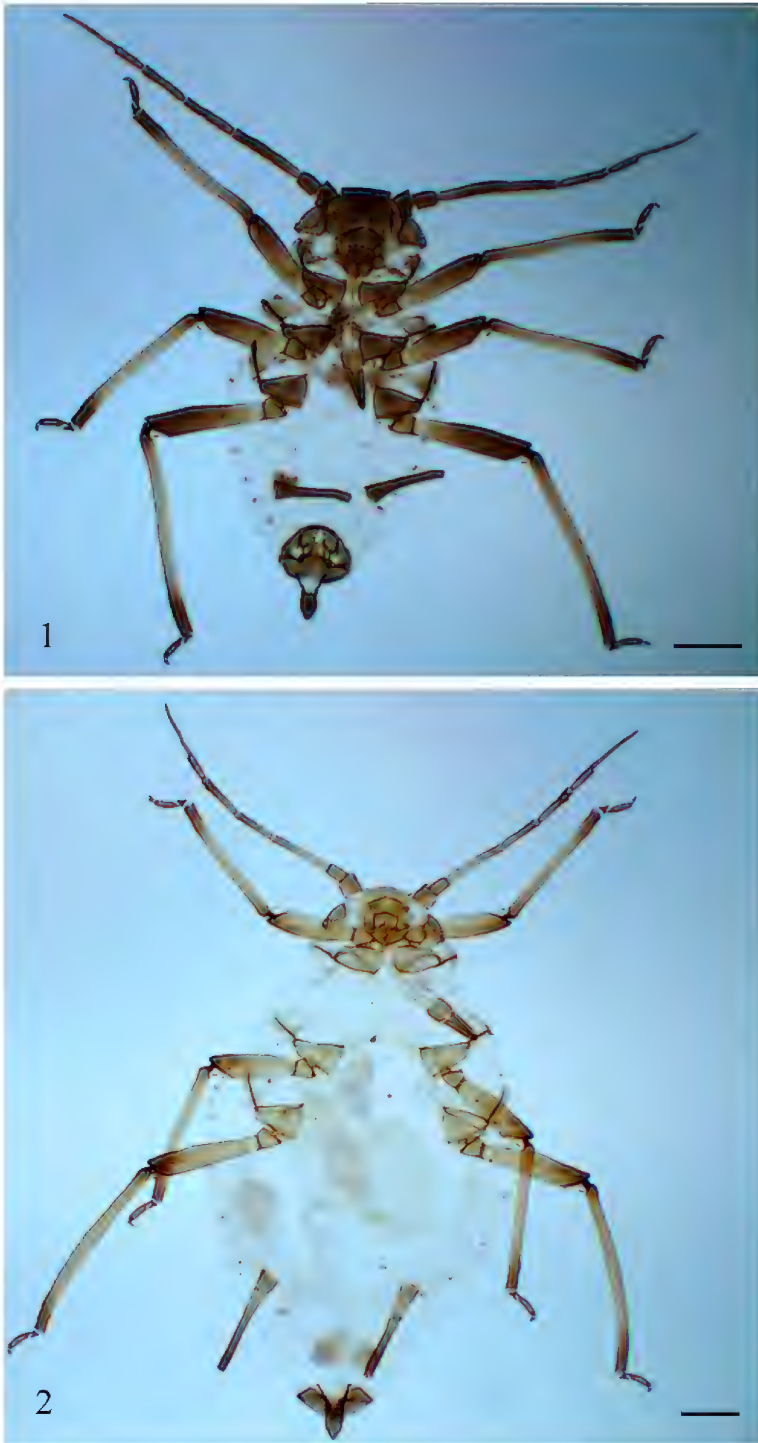
The previously unknown sexual morphs of the Australian aphid *Aphis acaenovinae* Eastop, 1961 are described from specimens collected on *Geum urbanum* (Rosaceae). The species is monoecious, producing wingless males and oviparae on its summer host.

Introduction

Aphis acaenovinae Eastop occurs only in Australia, on *Acaena ovina* (Eastop 1961), *Acaena anserovina* and *Geum urbanum* (all Rosaceae), and has been collected from all these during summer (Hales 2008). It is one of only four described species of indigenous Aphidinae and, like the others, is placed in the tribe Aphidini.

Barcode evidence based on cytochrome oxidase 1 (Genbank accession EU201295) (Foottit *et al.* 2008) links *A. acaenovinae* with the recently described *Aphis carverae* Hales, Foottit & Maw (in press) and to *Casimira canberrae* (Eastop), both known only from Australia (Teulon *et al.* 2013). No barcode sequence is available for the fourth Australian species, *A. platylobii* Carver & White. The Aphidini of Australia and New Zealand are highly unusual and have been proposed as possibly ancestral to the much more numerous and often economically important species of this tribe in the Northern Hemisphere (Eastop 2001, von Dohlen and Teulon 2003), although more data are needed before this hypothesis can be tested against the alternative, preferred by Eastop, that Australasian aphidines represent an outpost of a group originating in the north.

Aphids exhibit a range of complex annual cycles. Holocycly is the condition of having a complete annual cycle including parthenogenetic generations, sexual forms and eggs. A holocyclic monoecious species, after multiple parthenogenetically produced generations, remains on its summer host to produce males and mating females (oviparae), which lay eggs on the same host, the eggs being the only overwintering stage of the life cycle. Other possible annual cycles for aphids include continuous parthenogenesis (anholocycly) and holocyclic heteroecy. The latter is characterised by the use of separate hosts, whereby eggs are laid by mating females in autumn on one host, usually woody, and spring parthenogenetic generations arising from the eggs migrate to summer host plants, where they reproduce parthenogenetically, before returning to the winter host in autumn.



Figs 1-2. *Aphis acaenovinae*: (1) male; (2) ovipara. Scale bars = 200 μ m.

The annual cycle of *A. acaenovinae* has not been described previously and the sexual morphs were unknown. Males and oviparae were collected from *G. urbanum* in April 2008 at Thredbo, in the alpine region of New South Wales, and are described below.

Abbreviations: A 1-6 = Antennal segments 1-6; Ab 1-8 = Abdominal segments 1-8; ht2 = Second segment of hind tarsus; URS = Rostral segments iv+v ('ultimate rostral segment'); pt = Processus terminalis.

Units: Micrometres are used for measurements of setae and tubercles and millimetres for all other measurements.

Aphis acaenovinae Eastop, 1961

Male (Fig. 1).

Described from 5 specimens collected ex *Geum urbanum* at Thredbo NSW (coordinates -36.505 and 148.308, altitude 1380 m above sea level) 17.iv.08 by DFH.

Colour in fresh material. Dark green; genitalia and cauda black; brownish around siphunculi; eyes dark brown. Siphunculi, legs, A3 light brown; legs darker at femoro-tibial articulation, tarsi and distal ends of tibiae. Antennae darker from mid-A3 to end of antenna. Distal part of rostral segment iii and URS black.

Pigmentation of specimens preserved in 80% ethanol. Head, antennae, genitalia, anal plate, URS, siphunculi, cauda and legs pigmented. A3, A4, femora and tibiae darker distally. Thoracic pleura pigmented. Spiracular plates pigmented. A few small dark markings on dorsal surface of thorax. Sternite 8 and genitalia black.

Measurements. Body length from frons to tip of anal plate 1.2-1.3 mm. Frons appears flat in mounted specimens. Length of antennae 0.9-1.0 mm. Antennae 0.72-0.83 times body length. A3 0.21-0.23 mm, basal diameter A3 0.014-0.018 mm, A4 0.15-0.17 mm, A5 0.16-0.17 mm, base of A6 0.10-0.11 mm, pt of A6 0.18-0.21 mm, pt/base 1.75-2.05. Longest seta on A3 10-12 μ m. Secondary rhinaria distribution: A3 6-8, A4 3-7, A5 1-4. Dorsal cephalic setae 8-12 μ m. URS length 0.12-0.126 mm, basal width 0.05-0.064 mm; single pair of secondary setae. Prothoracic tubercles 20- 36 μ m in height and 20-36 μ m in width. Tubercles on Ab1 18-28 μ m in height and 18-30 μ m in width. Tubercles on Ab 7 26-30 μ m in height and 22-30 μ m in width. Hind tibia 0.6-0.63 mm, ht2 0.086-0.096 mm, URS/ht2 1.3-1.4. Hind trochantofemoral joint diameter 0.04-0.05 mm. Seta on hind trochanter 26-38 μ m, dorsal seta on hind femur 12-18 μ m, ventral seta on hind femur 24-28 μ m. Distal setae on hind tibia 28 -38 μ m; setae at mid-length of hind tibia 30-40 μ m. Siphunculi: length 0.23-0.38 mm, siphunculi 0.19-0.23 times body length, mid-width 0.022-0.026 mm, basal width 0.038-0.056 mm, apical width 0.024-0.028 mm, base/apex 1.46-2.33. Cauda slightly constricted about

40% of its length from the base. Cauda length 0.14-0.15 mm, basal width 0.094-0.106 mm (n=2), siphunculus/cauda 1.67-1.94, 5-7 setae on cauda. 2-4 setae on 8th abdominal tergite 10-14 μ m in length, setae on Ab 3 6-10 μ m. Anal plate with 12 setae to 36 μ m.

Genitalia. Claspers each with > 20 setae. Aedeagus not everted in available specimens.

Two further specimens were subsequently reared following a week on cut samples of the host plant. These were smaller (body length to tip of anal plate: 0.9-1.0 mm) than those developing in the field and their measurements are not included in the description above, although most other measurements and ratios fell within the range of those from larger specimens.

Ovipara (Fig. 2).

Described from 12 specimens collected ex *Geum urbanum*, Thredbo NSW 17.iv.08 by DFH.

Colour in fresh material. As for male but slightly lighter dull green. Genital plate bilobed and slightly pigmented on the sides. Ventral surface dirty fawn to green.

Pigmentation of macerated specimens. Head, antennae, cauda, anal plate, URS, siphunculi, cauda and legs pigmented although generally less so than in male. A3, A4, femora, tibiae, siphunculi darker distally. Spiracular plates pigmented. Without small dark markings on dorsal surface of thorax. Genital plate with dark area on each side.

Measurements. Body length from frons to tip of anal plate 1.60-1.86 mm. Antennal tubercles small with a short outward-facing seta on dorsal surface of each, frons sinuate with a small protuberance on each side of midline, a pair of anterior dorsal setae and a slightly more ventral inward-pointing pair whose bases are inset lateral to the median protuberances. Dorsal cephalic seta 8-12 μ m. Antennae 6-segmented, segments 1-2 smooth, 3-6 imbricated. Length of antennae 0.90-1.02 mm. Antennae 0.48-0.61 times body length. A3 0.20-0.23 mm, basal diameter A3 0.016-0.020 mm, A4 0.13-0.15 mm, A5 0.14-0.17 mm, base of A6 0.10-0.11 mm, pt of A6 0.18-0.23 mm, pt/base 1.75-2.05. Longest seta on A3 10-14 μ m. Secondary rhinaria nil. URS length 0.136-0.148 mm, basal width 0.054-0.066 mm. One pair of secondary setae 20-28 μ m long. Prothoracic tubercles 26-36 μ m in height. Marginal tubercles also on Ab1 (20-32 μ m in height, 20-40 in width) and 7 (26-40 μ m in height, 20-30 μ m in width). Hind tibia 0.63-0.68 mm, ht2 0.10-0.11 mm, URS/ht2 1.3-1.45. Hind trochantro-femoral joint diameter 0.046-0.054 mm. Seta on hind trochanter 26-40 μ m, dorsal seta on hind femur 12-20 μ m, ventral seta 22-36 μ m. Distal setae on hind tibia 34-48 μ m; setae from mid-length of hind tibia 34-42 μ m. Scent plaques on hind tibiae 11-49. Hind tibiae not markedly swollen, ratio of mid-length width to distal width 1-1.4. First tarsal segment

chaetotaxy 332. Siphunculi: length 0.32-0.38 mm, 0.19-0.23 times body length, mid-width 0.028-0.036 mm, basal width 0.05-0.08 mm, apical width 0.03-0.038 mm, base/apex 1.67-2.50. Cauda constricted about 4/10 of the distance from the base. Cauda length 0.18-0.23 mm, basal width 0.078-0.116 mm, siphunculus/cauda 1.69-1.96, 5-8 setae on cauda. 2-4 setae on 8th abdominal tergite, setae on abdominal tergite 3 8-10 μ m.

Genitalia. Gonapophyses 4, lateral gonapophyses large with 6 setae, medial smaller with 3-4 setae. Genital plate with 10-16 setae on general surface plus 14-27 marginal setae.

Siphunculi, cauda, anal and genital plate imbricated.

As with the males, additional specimens (n = 3) were reared from cut samples of *G. urbanum* but measurements are not included above. Body length (1.12-1.44 mm) was smaller than in field-grown individuals. Most other measurements and ratios fell within the ranges given above.

Eggs

Light orange when seen through ovipara body wall and when first laid; of typical aphidine elongate-ovoid shape. Eggs are laid on leaves, stipules and stems of *Geum* and turn black after laying.

Depositories

Specimens are deposited in the Australian National Insect Collection, Canberra, the Natural History Museum, London and the Canadian National Collection of Insects, Ottawa.

Discussion

The discovery of wingless males, oviparae and eggs on a summer host, *G. urbanum*, clearly demonstrates that *Aphis acaenovinae* is holocyclic and monoecious on a herbaceous host. We have not observed sexual morphs on *Acaena* spp, which were presumably the original native host, but the same cycle most likely also applies. Both *Geum* and *Acaena* are perennial herbs in the family Rosaceae, *Geum urbanum* being of northern hemisphere origin and introduced to Australia, while *Acaena* species have a predominantly southern distribution. A native species of *Geum*, *G. talbotianum* WM Curtis, is endemic to Tasmania (Department of Primary Industries, Parks, Water and Environment, Threatened Species 2014) and would be a possible host of *A. acaenovinae*.

The Argentinian *Acaena*-feeding species *Aphis acaenaevora* is also holocyclic and monoecious (Mier Durante and Ortego 1998), as are the Australian *A. carverae* and *C. canberrae* from *Epilobium* (Hales *et al.* in press). The annual cycles of New Zealand aphidines are not known. Kim *et al.* (2011) examined a wide range of *Aphis* and related genera but were not able to conclude which type of annual cycle was ancestral: monoecy on trees,

heteroecy, or monoecy on grasses. Data so far available and those presented here indicate a Gondwanan group of holocyclic monoecious species, but more information is needed on the annual cycles of other austral indigenous aphidines.

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References

- DEPARTMENT of PRIMARY INDUSTRIES, PARKS, WATER and ENVIRONMENT. 2014. Threatened species [Accessed 4 June 2014]. Available from URL: <http://dpiwve.tas.gov.au/conservation/threatened-species>
- EASTOP, V.F. 1961. Two new *Aphis* species (Hem. Aphididae) from Australia. *Entomologist's Monthly Magazine* **96**: 173-176.
- EASTOP, V.F. 2001. A new native *Paradoxaphis* Sunde (Hemiptera: Aphididae) from New Zealand. *New Zealand Entomologist* **24**: 11-13. <http://dx.doi.org/10.1080/00779962.2001.9722077>
- FOOTTIT, R.G., MAW, H.E.L., von DOHLEN, C.D. and HEBERT, P.D.N. 2008. Species identification of aphids (Insecta: Hemiptera: Aphididae) through DNA barcodes. *Molecular Ecology Resources* **8**(6): 1189-1201.
- HALES, D.F. 2008. Biological observations on the Australian endemic aphid *Aphis acaenovinae* Eastop, including new host-plant records (Hemiptera: Aphididae). *Australian Entomologist* **35**: 93-95.
- HALES, D.F., FOOTTIT, R.G. and MAW, E. In press. Endemic aphids *Aphis carverae* sp. nov. and *Casimira canberrae* (Eastop, (1961) on *Epilobium* (Onagraceae) threatened by introduced *Aphis oenotherae* Oestlund, 1887 (Hemiptera: Aphididae: Aphidinae). *Austral Entomology*.
- KIM, H., LEE, S. and JANG, Y. 2011. Macroevolutionary patterns in the Aphidini aphids (Hemiptera: Aphididae): diversification, host association, and biogeographic origins. *Public Library of Science ONE* **6**(9): e24749. doi:10.1371/journal.pone.0024749
- MIER DURANTE, M.P. and ORTEGO, J. 1998. Une nouvelle espèce d'*Aphis*, inféodée au genre *Acaena* en Argentine [Hemiptera, Aphididae; Rosaceae]. *Revue française d'Entomologie (N.S.)* **20**: 121-126.
- TEULON, D.A.J., STUFKENS, M.A.W., DRAYTON, G.M., MAW, H.E.L., SCOTT, I.A.W., BULMAN, S.R., CARVER, M., VON DOHLEN, C.D., EASTOP, V.F. and FOOTTIT R.G. 2013 Native aphids of New Zealand—diversity and host associations. *Zootaxa* **3647** (4): 501-517.
- VON DOHLEN, C.D. and TEULON, D.A.J. 2003. Phylogeny and historical biogeography of New Zealand indigenous Aphidini aphids (Hemiptera, Aphididae): an hypothesis. *Annals of the Entomological Society of America* **96**(3): 107-116.